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EFFECTS OF SIMULATED SPACE ENVIRONMENTS ON THE VIABILITY OF MICROORGANISMS

Quarterly Status Report

January 16 through April 15, 1963

by

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INTRODUCTION AND SUMMARY

This report under Contract No. NASr-41, "Effects of Simulated Space Environments on the Viability of Microorganisms," National Aeronautics and Space Administration, Washington, D.C., summarizes the experiments conducted during the period, January 16 through April 15, 1963. The program was a joint effort of National Research Corporation and the Department of Nutrition and Food Science, Massachusetts Institute of Technology, Cambridge, Massachusetts.

During this report period work was performed in three general areas of interest. The combined effects of thermal and ultrahigh vacuum exposure were studied in continuing experiments with organisms isolated from Mohave Desert soils. Studies of the combined effects of gamma radiation and ultrahigh vacuum on selected microorganisms were resumed in an improved vacuum system. A modified ultraviolet radiation system has been developed and tested to permit studies at lower ultraviolet intensities.

VACUUM THERMAL EFFECTS OF DESERT SOIL EXPERIMENTS

The program in which organisms are being recovered from Mohave Desert soils after exposure to ultrahigh vacuum at elevated temperatures was continued. Six 1-gram soil samples were subjected to a pressure of about 6×10^{-9} torr and a temperature of 170°C for 4.5 days. The aerobic and anaerobic mesophilic and thermophilic organisms which survived this treatment were determined quantitatively.

The distribution of organisms recovered was as follows:

	Bacteria (per gram)	Molds (per gram)	Actinomycetes (per gram)
Mesophilic aerobes	22	14	4
Thermophilic aerobes	1	0	0
Mesophilic anaerobes	9	--	0
Thermophilic anaerobes	5	--	0

The forty-one aerobic isolates from this experiment were placed on glass filters and maintained at 120°C at atmospheric pressure for 3 hours. The filters were then plated by means of the impressing technique described in the previous report. Only five bacterial cultures survived this treatment. It would appear that in spite of apparent heat resistance when in contact with soil in vacuum, it does not necessarily follow that unprotected organisms would approach the same level of thermal resistance.

COMBINED EFFECTS OF GAMMA IRRADIATION AND ULTRAHIGH VACUUM EXPOSURE

A series of experiments is in progress in which spores of Bacillus stearothermophilus, B. megaterium, B. subtilis var. niger, Clostridium sporogenes, and Aspergillus niger are exposed to an ultrahigh vacuum of the order of 2×10^{-9} torr for a 5 day period and are then irradiated with various dosages of Co^{60} gamma rays.

In the studies completed, one set of samples was irradiated while still under vacuum and a second set, after evacuation for five days, was irradiated after venting to atmospheric pressure with dry air.

A third set of samples was held in a desiccator without evacuation for the same period of time and was then irradiated.

In carrying out the vacuum exposures, glass filters containing spores were supported in glass tubes which were connected to a common UHV pumping system. A hot filament UHV ionization gauge was attached directly to each exposure tube so that the pressure in each tube could be determined individually at any time.

In earlier experiments the individual exposure tubes were attached to the common pumping system through a glass manifold. At the end of the vacuum exposure period the individual exposure tubes were removed from the glass manifold for transport to the irradiating facility. Removal was accomplished by heat sealing while tubes and manifold were under vacuum. Pressures in the individual exposure tubes rose from the low 10^{-9} torr range before heat sealing to the high 10^{-5} torr range after heat sealing.

The experiments described in this report were performed in an improved system which eliminates the outgassing and consequent pressure rise attending heat sealing. In the improved system each individual exposure tube is attached to the common pumping system through two ultrahigh vacuum valves in series. The tubes are thoroughly baked under vacuum prior to loading of the samples. At the end of the vacuum exposure period an individual exposure tube is removed from the common pumping system by closing both valves and disconnecting the valves at their common flange. Pressures in the individual tubes when loaded with six samples, rose from the low 10^{-9} torr range before valve closure to the middle 10^{-8} torr

range or less after valve closure. The evacuated sample assembly, consisting of the sample exposure tube, the ultrahigh vacuum gauge, and the ultrahigh vacuum valve, is transported to the Co^{60} facility where it is exposed to gamma radiation.

Satisfactory experiments have been completed at 50,000, 100,000 and 200,000 rads gamma radiation. The complete data tabulation will be included in a future report so that results at a particular radiation dose will be considered in the context of the over-all experiment.

IMPROVEMENT OF THE ULTRAHIGH VACUUM ULTRAVIOLET EXPOSURE SYSTEM

Early work on the viability of microorganisms exposed to ultraviolet radiation in ultrahigh vacuum resulted in essentially complete mortality for even short ultraviolet exposure times. Consequently, the ultraviolet source has been modified to reduce its intensity to a more suitable value. A General Electric mercury germicidal lamp, type G15T8, was used as the radiator. The electrodes at each end of this lamp are coiled filaments which in normal operation with a standard lamp ballast are heated by the current passing through the mercury vapor. Attempts to reduce the intensity of the lamp's output by reducing the current passing through the vapor were not successful because the temperature of the electrodes dropped below the value necessary to maintain the discharge.

By using filament transformers to heat the two end filaments so that their temperature is not a primary function of the current

passing through the vapor, and by putting a variable inductor in series with the lamp ballast so that the current passing through the mercury vapor can be controlled, it is possible to reduce the intensity of the lamp output considerably. A reduction from 1000 to 60 microwatts per square centimeter was achieved in this manner. A further reduction to 20 microwatts per square centimeter was realized by interposing a wire mesh screen between the source and the sample. The modified source will be ready for use as soon as dosimetry calibrations have been completed.

FUTURE WORK

Gamma radiation experiments will be continued at low and high radiation doses in order to demonstrate differences in radiosensitivity associated with the extent to which the spores have been dried and with the pressure of the atmospheric environment.

The improved ultrahigh vacuum ultraviolet exposure system will be calibrated. As soon as these dosimetry calibrations have been completed, a series of experiments will be started to determine the sensitivity range to ultraviolet radiation of selected microorganisms.